9K331 Tor-M1, 9K332 Tor-M2 (SA-15 Gauntlet)

The Tor was developed for the successor army air defense system of both the 9K33 Osa and 2K12 Kub families even it has less considerably smaller engagement range than the 2K12 Kub-M3.[1]

The first Tor variant was manufactured in very small quantity it got the 9K330 designation. This initial variant was the foundation of the further developments but rather was just a “rebalanced and upgraded Osa”, a technology demonstrator the next iteration for division level air defense following the very problematic predecessor. The 9K330 GRAU designation is similar a reminder about the evolution what was explained at the Ellipse ---> Osa renaming history. In that case the 9K33 just got an extra ‘0’ in designation showing it is related to the Osa.

In the previous chapter was mentioned Ustinov demanded 8 missiles for the upgraded Osa variants but only 6 was doable. Fulfilling this requirement was one of the main point of the new SAM system. Beside the increased carried missiles quantity the most crucial changes happened in the radar and guidance. After the painful and long developing the Osa it became obvious increasing missile and target channels by the conventional way using more antennas just would lead an even more complicated system. Another solution had to find to increase the target channel and other capabilities of the Tor.

In the early-mid ‘70s was developed for homeland air defense the first version of the S-300 family for the PVO with PESA technology fire control radar (30N6 / Flap Lid). The development of the S-300 was successful therefore the similar base technology was adopted for the Tor. Of course the applied technical solutions of the S-300 had to be downscaled accordingly keeping the focus on the requirement of the army air defense where everything had to be installed on a single vehicle.

The Tor-M1 is literally a miniaturized S-300PT with similar missiles to 9K33 Osa in kinematics and size (with a bit larger weight) but with similar radar and guidance to S-300 except the Tor vehicle is self-contained. Radars for fire control and target acquisition are on the same platform as well as the missiles. The engagement zone of the Tor is much smaller and has much less target (2) and missile channels (4) than the S-300PT (6 and 12) but it is much more mobile and cheaper (per vehicle).

The 9K331 Tor-M1 has the following main elements:

1. СОЦ, (SOC), target acquisition radar (with cm wavelength)
2. Wide beam missile guidance antenna
3. Narrow beam monopulse target and missile tracking radar, also for RCG signals
4. Optical target tracking system
5. Missile containers (on each sides with 4 missiles, in total 8 missiles)

[1] *Range is not everything other capabilities are also important as well as the cost efficiency concerning of target channels and defended area.*



9K331 Tor-M1.

As we can see the quantity and types of the antennas comparing to Osa was strongly reduced. The advance in solid state electronics technology and PESA radar made possible to achieve these changes. Following the missile launch with ‘2’ labelled antenna is guided the missile into scan zone of the ‘3’ labelled PESA antenna which tracks both the target and missiles and emits the further RCG signals for the missiles.

Comparing to lots of antennas on Osa only a single small wide beam antenna is enough to guide the missile into the narrow beam (‘3’) antenna and this larger antenna fulfills three roles. Thanks to the PESA radar rapid and free azimuth and elevation scan capability within its limits the radar can track both the missiles and targets and is able to illuminate all of them dozens of time within just a second while also transmits RCG signals. The 9K330 had only 1 target channel but the improved and first major variant the 9K331 Tor-M1 has 2 target and 4 missile channels. Tor-M1 became the first army air defense system with simultaneous engagement capability with a single fire control radar.

This was a great step forward comparing to the Osa’s single target and two missile channels. Comparing to a single 2K12 Kub regiment (with five batteries) two Tor-M1 vehicles have the same target channel qty. as a full Kub regiment where one of the battery is under relocation. Of course the covered airspace is smaller but the target channel “density” is much higher for Tor-M1. In the ‘80s the maximal 6 km engagement altitude was more than enough none of the existing and predicted tactical aircraft could use efficiently any of their strike weapons above 6 km not even laser guided bombs at that time. (An only a handful of airplanes could use laser guided bombs.)

Similarly to Osa the Tor-M1 also has the autonomous target acquisition capability by the SOC radar. Even the SOC still is the data link with higher IADS elements is the preferred and best way to get target coordinates when the Tor-M1 itself can remain hidden until the missile launch.

The 9M331 missile is launched vertically with gas catapult system similar to S-300.[2] Following the launch on the tip of the missiles the gas dynamic control system rotates the missile towards to the target then main rocket engine is ignited and accelerates the missile up to M2.4. The launch weight is 167 kg, warhead weight is 15 kg.

This combined launch method was necessary to achieve the very small engagement range with vertically stored missiles in canisters instead using rails/canisters on not fully rotated tower similar to Osa. The gas dynamic system prevents to waste kinetic energy for turning the missile from vertical direction towards to target when the missile very quickly accelerates from zero speed until burnout the main rocket engine. For rotating the missile around it's centre of gravity requires very small but precisely controlled thrust. The gas dynamic system solution not only increases the maximal engagement but also decreases the minimal engagement range.



Launching of the 9M331 missile. It is visible the still operational gas dynamic system on the tip of the missile while the main engine of the rocket has been ignited.

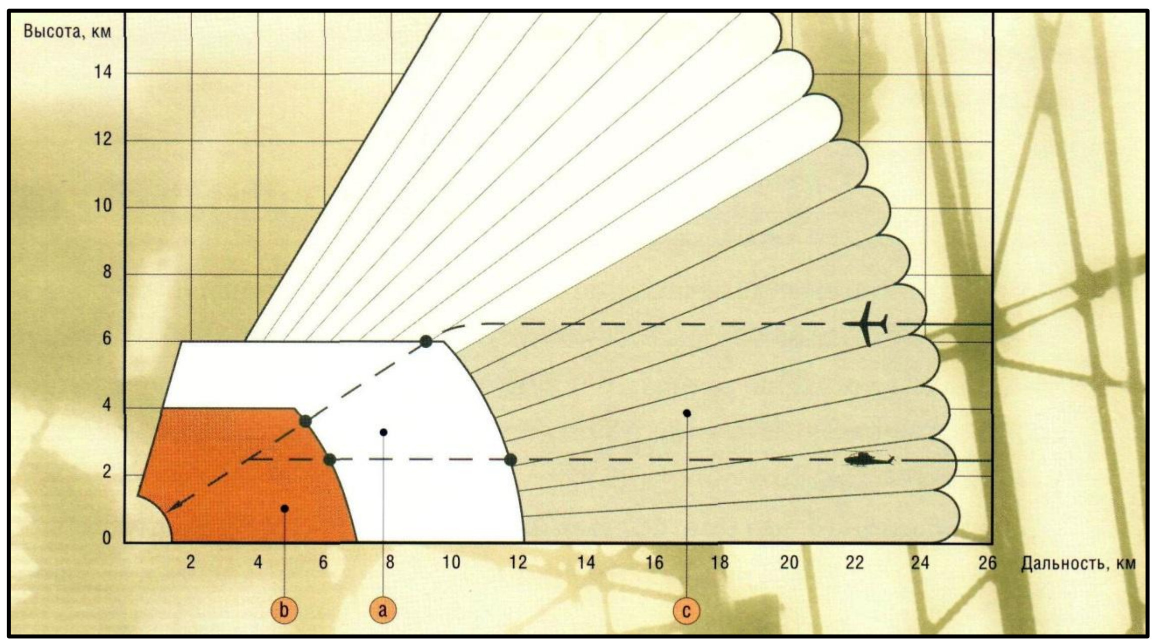
Comparing to Osa the launcher vehicle is totally different. The amphibious capability was not requested because both the ZSU-23-4 Shilka and the predecessor 2K22M Tunguska do not have this feature. (Even the Tor-M1 is divisional level SAM as the Osa they are assigned to battalions, see in the structure and organizations chapter.)

The Tor-M1 is much more automatized then Osa because the "anti-ARM" and for the navy "anti-ASM" capability demanded this. The Tor-M2 has even fully automatized operational mode.[3]

A very useful and new feature that Tor-M1 is able to shoot down incoming anti-radiation missiles. In the era of AGM-88 this was a big capability boost comparing to Osa and Kub.

[2] *This is what called „cold launch". For S-300MPU on a „plate" is placed the missile and are two pistons in the canister. Using powder charges as gas generators the expanding gas provides the power for the pistons. The pistons pushed the plate and the missile on the plate. This ejects (launches) the missile 20-25 meters above the launcher vehicle. Very likely the Tor uses the same technical solution. (Hpasp)*

[3] *https://www.youtube.com/watch?v=y8f6l-UN_9M*



Engagement and search zone of the Tor-M1 system, maximal engagement altitude is 6 km up to 12 km distance against airplanes.

The maneuvering capability of the missile slightly to 30G max turning capability. The burnout speed is between 700-800 m/s (M2.1-2.4) depending on the trajectory of the missile. The minimal engagement distance is 1.2 km, minimal target altitude is 10 meter. The maximal target offset distance (parameter) is 6 km. Maximal target speed is 700 m/s but in this case the parameter distance is likely smaller.





Above left is on self propelled wheeled vehicle on the right tracked variant accordingly to demands of the polar regions.

Besides the „classical" self propelled tracked chassis other options are available as platform for the missile system since the early 2010s. Accordingly the special Russian requirements in polar and certain regions were these developed and of course for potential foreign customers.

In 2007 on the MAKS exhibition was presented first the latest variant of the SA-15 family the 9K332 Tor-M2 variant which entered service from 2012 in Russia. The M2 has almost the same appearance as the M1 variant the main differences the new antenna of the SOC and the additional wide beam missile guidance antenna. Thanks to the new wide beam antenna and other upgrades the Tor-M2 has 4 target and 8 missile channels. Besides the increased target quantity the Tor-M2 has a new smaller missile the 9M338 likely with smaller engagement range.

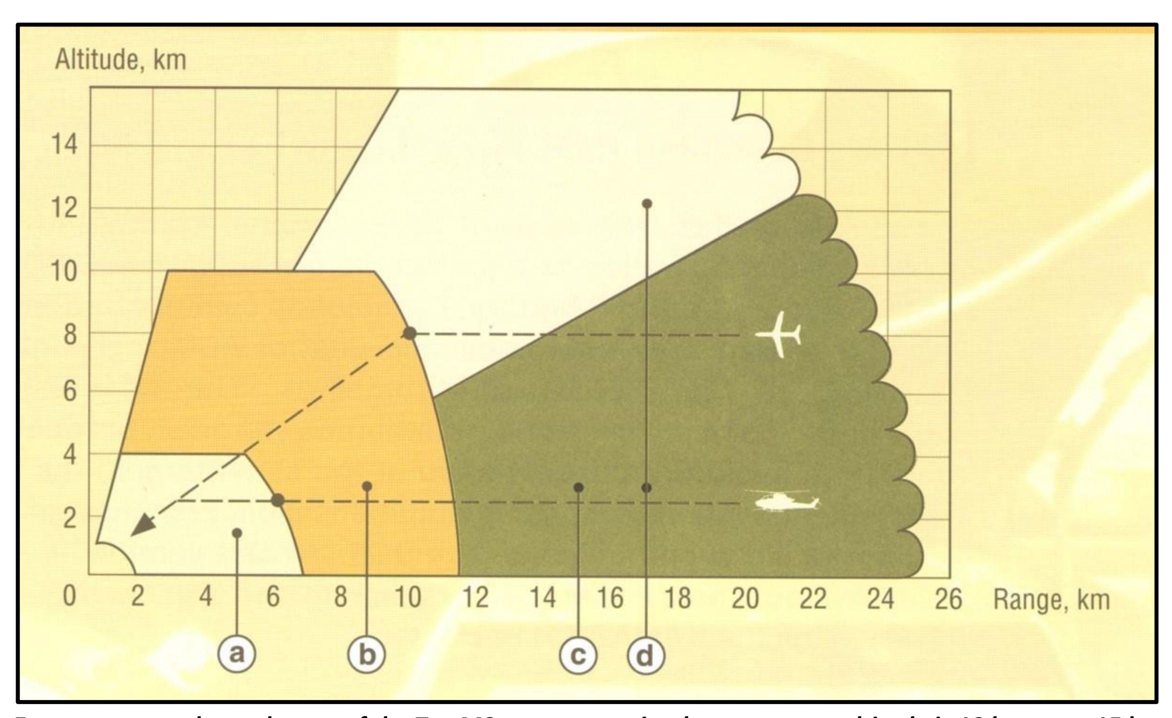




Above left is the Egyptian Tor-M2 on the right is a Russian Tor-M2 on both is visible the new additional wide beam antenna.

Because of the smaller size of the 9M338 in a single canister 8 missile can be loaded in case the system uses only smaller missiles with less engagement range the total inventory is increased to 16 missile if only the new missile are used. Very likely is possible to use mixed missile inventory in this case the maximal missile capacity is 12 missiles 4x9M331 and 8x9M338. The engagement range with larger missile reaches 10 km maximal altitude and 15 km range.[4]

The idea behind the more but smaller quantity of missile very likely the increased quantity of smaller targets on battlefield such as UAVs and UCAVs and smaller but more abundant strike weapons per attack aircraft such as GBU-39/53 SDB I/II.



Engagement and search zone of the Tor-M2 system, maximal engagement altitude is 10 km up to 15 km distance against airplanes.[5]

The Tor-M2 is able to launch missile during slow movement on paved road (which was originally was demanded from the Ellipse 50 years ago) before Tor-M2 every SHOARD SAM had to stop for the launch.

[4] https://goo.gl/mZVQje
[5] https://goo.gl/sfZf2t

The Tor-M1 became available after the Cold War and very soon was offered for export similar to S-300PMU1. So far only a few were sold outside Russia which is hard to understand because of the capability of the system. Even the Tor-M1 provides unique capabilities and range in radar SHORAD category and the Tor-M2 is even more advanced. About half a dozen countries bought Tor-M1 or M2 if we do not count the successor states of the Soviet Union. None of the foreign operators bought more than two dozen except China.

As usual finally are some video and more images about the system:

http://www.ausairpower.net/APA-9K331-Tor.html#mozTocId239351
https://www.youtube.com/watch?v=9MZtnqJLf4c
https://www.youtube.com/watch?v=N7vvvgodLU8
https://www.youtube.com/watch?v=8YI72CSiexQ
http://www.ausairpower.net/APA-9K331-Tor.html